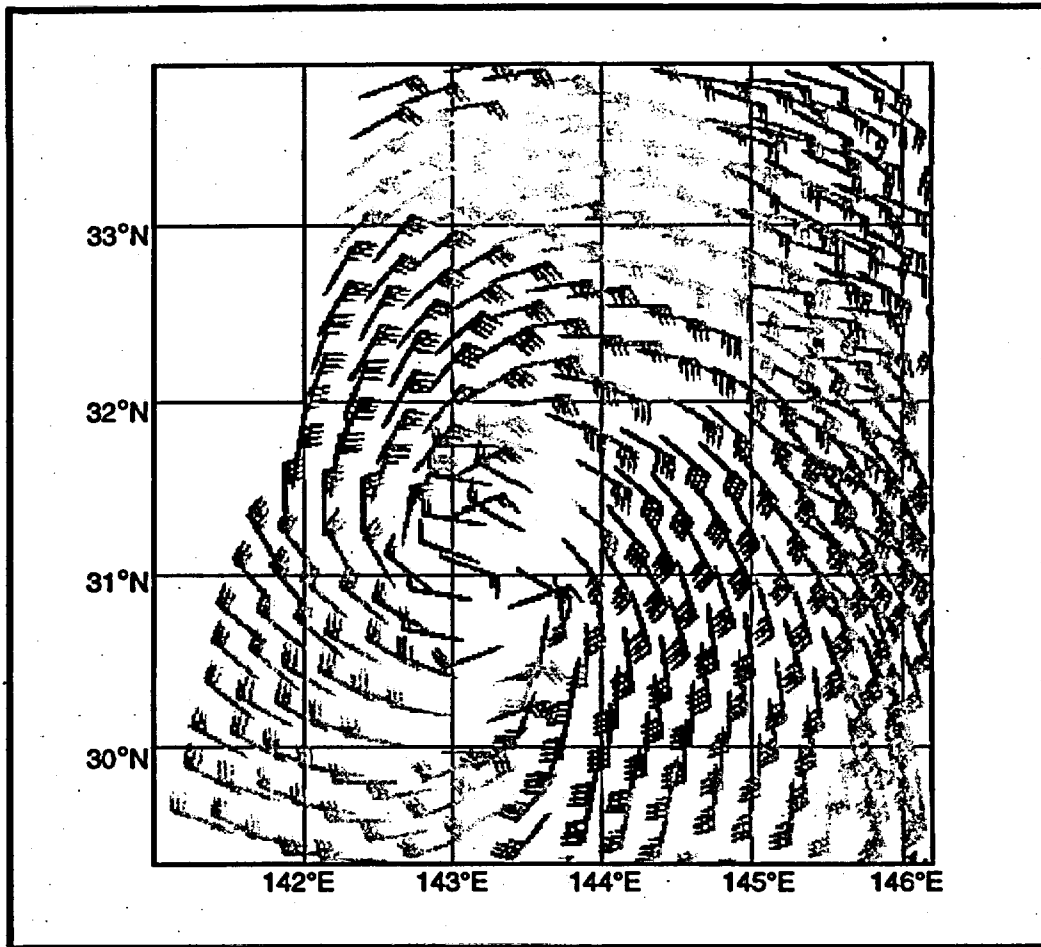


1996 ANNUAL TROPICAL CYCLONE REPORT



JOINT TYPHOON WARNING CENTER
GUAM, MARIANA ISLANDS

*The 1996 Annual Tropical Cyclone Report is dedicated to:
Captain Christopher T. Nicklas, USAF
1967 to 1997*

FRONT COVER: Vectors describe Typhoon Orson's (19W) surface wind field at approximately 01000Z September 1996. An automated algorithm, using the European Remote Sensing Satellite -1 (ERS-1) synthetic aperture radar (scatterometer) data, estimates these vectors which can be used to determine the radii of gale-force winds surrounding the typhoon. Although these data have proven invaluable, they are limited by the algorithm's inability to resolve scalar wind speeds above 50 knots and the wind direction 180 degree ambiguities.

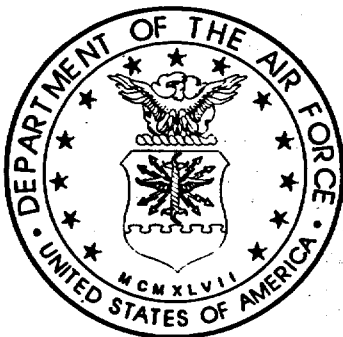
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*Work on this report was supported in part by
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* TRANSFERRED DURING 1996

** ACTIVE DUTY TRAINING

FOREWORD

The Annual Tropical Cyclone Report is prepared by the staff of the Joint Typhoon Warning Center (JTWC), a combined Air Force/Navy organization operating under the command of the Commanding Officer, U.S. Naval Pacific Meteorology and Oceanography Center West (NAVPACMETOCCEN WEST)/Joint Typhoon Warning Center, Guam. The JTWC was founded 1 May 1959 when the U.S. Commander-in-Chief Pacific (USCINCPAC) forces directed that a single tropical cyclone warning center be established for the western North Pacific region. The operations of JTWC are guided by USCINCPAC Instruction 3140.1W.

The mission of JTWC is multifaceted and includes:

1. Continuous monitoring of all tropical weather activity in the Northern and Southern Hemispheres, from 180° east longitude westward to the east coast of Africa, and the prompt issuance of appropriate advisories and alerts when tropical cyclone development is anticipated.

2. Issuance of warnings on all significant tropical cyclones in the above area of responsibility.

3. Determination of requirements for tropical cyclone reconnaissance and assignment of appropriate priorities.

4. Post-storm analysis of significant tropical cyclones occurring within the western North Pacific and North Indian Oceans.

5. Cooperation with the Naval Research Laboratory, Monterey, California on evaluation of tropical cyclone models and forecast aids, and the development of new techniques to support forecast requirements.

Special thanks to: the men and women of the Alternate Joint Typhoon Warning Center for standing in for JTWC as needed; Fleet Numerical Meteorology and Oceanography Center (FNMOC) for their operational support; the Naval Research Laboratory for its dedicated research; the Air Force Global Weather Central (AFGWC) and National Oceanic and

Atmospheric Administration (NOAA) National Environmental Satellite, Data, and Information Service (NESDIS) for satellite support; the 36th Communications Squadron's Defense Meteorological Satellite Program (DMSP) Site 18 at Nimitz Hill, Guam; and the Operations and Equipment Support departments of NAVPACMETOCCEN WEST, Guam for their high quality support; all the men and women of the ships and facilities ashore throughout the JTWC area of responsibility (AOR), and especially on Guam, who took the observations that became the basis for our analyses, forecasts and post-analyses; CDR Lester E. Carr III and Dr. Russell L. Elsberry for their efforts at the Naval Postgraduate School and publication of the Systematic and Integrated Approach to Tropical Cyclone Track Forecasting Part II; the personnel at the Navy Publications and Printing Service Branch Office, Guam; Dr. Robert F. Abbey Jr. and the Office of Naval Research for their support to the University of Guam (UOG) for the Research Liaisons to JTWC; the UOG Research Liaisons for their contributions to this publication; Dr. Mark A. Lander for his training efforts, suggestions and valuable insights, and Mr. Charles P. Guard for his support and data collection efforts; Dr. Jeff D. Hawkins, Chris S. Veldon, Samuel Chang and Roger Weldon for their tireless efforts to get the most possible out of remote sensing technologies; Capt Carl Davis for his assistance in obtaining the satellite imagery for the northern Indian Ocean tropical cyclones; Mr. John "Jack" Beven for his efforts to include ground truth in his Weekly Tropical Cyclone Summaries; Mr. Charles R. "Buck" Sampson, Sally A. Calvert, Rosemary Lande, Mike D. Frost, Mugur Georgescu, Daren H. Grant, and Ann J. Schrader for their support and continued development of the Automated Tropical Cyclone Forecasting (ATCF) system; and, AG2 Bryan Y. Hong, AG3 Chris Cross, and A1C Matthew A. Boyd for their excellent desktop publishing and graphics assistance.

EXECUTIVE SUMMARY

The 1996 tropical cyclone season was spectacular. During the western North Pacific (WNP) season there was a near record number of significant tropical cyclones (TCs) -- 43 compared to the 1964 record of 44; 40% above average. Of these, 21 reached typhoon intensity -- the most typhoons in one season since 1972. Additionally, six reached super-typhoon intensity -- two above average. The north Indian Ocean (NIO) also experienced an active season with eight significant TCs -- 60% above average!

The Southern Hemisphere had an average season with 28 significant TCs, although the start of the 1997 season (coincident with the latter half of the 1996 Northern Hemisphere season) was more active than normal.

Despite the high ops tempo induced by an extremely active season, warning support to U.S. assets afield and afloat was superb. Warning verification statistics indicate JTWC was on par with the best season on record in terms of warning skill. The average 1996 forecast errors of 105 nm, 178 nm and 272 nm at 24-, 48- and 72-hour positions, respectively, were second only to 1994.

The JTWC continued to use and assist in the advancement of new technologies for the analysis and forecast of TCs during 1996. Satellite-measured observations of atmospheric winds from the ocean surface to the upper troposphere significantly contributed to earlier diagnosis of TC genesis and wind field definition. Examples include scatterometry-derived winds provided by the European Space Agency Remote Sensing Satellite (ERS-1&2), water vapor-, infrared-, and visible-derived drift wind vectors provided by the University of Wisconsin, and the Defense Meteorological Satellite Program's Special Sensor Microwave Imager-derived wind speed measurements.

Over 9500 satellite-based TC fixes were provided by the USPACOM Meteorological Satellite Network to support warnings in JTWC's Area of Responsibility (AOR), the bulk of which were provided by the JTWC Satellite Operations section. A new satellite-interpretation technique for TCs undergoing extratropical transition was developed in-house and used by the Network during 1996. Also developed during 1996 was systematic methodology to establish TC positions based on microwave imagery, and a new satellite-derived position code number criteria scheme.

The excellent error statistics of 1996 can in part be contributed to continued application of the Systematic and Integrated Approach to Tropical Cyclone Forecasting, developed by CDR Lester E. Carr III and Dr. Russell L. Elsberry of the Naval Postgraduate School. Also of note was the operational implementation of the Geophysical Fluid Dynamics - Navy (GFDN) model. GFDN is a slightly modified version of the model used by the National Hurricane Center for Atlantic TCs, and it provides guidance on selected TCs of tropical-storm or higher intensity throughout JTWC's AOR.

Another significant contribution to our overall error statistics has been the hard work and dedication of the "JTWC" team, consisting of Air Force and Navy officer, enlisted, and civilian personnel. Despite limited manning resources, JTWC met its mission objectives with flying colors. Unfortunately, with additional taskings such as the BRAC-directed move of the JTWC to Pearl Harbor in early 1999, the ability to support the production of a document such as this has been dramatically reduced. A significant reduction of scope in future Annual Tropical Cyclone Reports is planned, unless we hear differently from you, the reader.

TABLE OF CONTENTS

	<u>Page</u>
FOREWORD	iii
EXECUTIVE SUMMARY	iv
1. OPERATIONAL PROCEDURES	1
1.1 General	1
1.2 Data Sources	1
1.3 Telecommunications	3
1.4 Data Displays	6
1.5 Analyses	7
1.6 Forecast Procedures	7
2. RECONNAISSANCE AND FIXES	15
2.1 General	15
2.2 Reconnaissance Availability	15
2.3 Satellite Reconnaissance Summary	15
2.4 Radar Reconnaissance Summary	22
2.5 Tropical Cyclone Fix Data	22
3. SUMMARY OF WESTERN NORTH PACIFIC AND NORTH INDIAN OCEAN TROPICAL CYCLONES	25
3.1 Western North Pacific Ocean Tropical Cyclones	25

Individual Tropical Cyclone Narratives

<u>Tropical Cyclone</u>	<u>Author</u>	<u>Page</u>	<u>Tropical Cyclone</u>	<u>Author</u>	<u>Page</u>
01W TD	Lander	44	23W STY Sally	Lander	138
02W TS Ann	Lander	46	24W TS	Lander	142
03W TD	Lander	49	25W TY Tom	Lander	145
04W TY Bart	Lander	51	26W STY Violet	Lander	150
05W TS Cam	Lander	55	27W TY Willie	Lander	155
06W TY Dan	Lander	61	28W STY Yates	Lander	158
07W STY Eve	Lander	66	29W TY Zane	Lander	163
08W TY Frankie	Lander	72	30W TS Abel	Lander	168
09W TY Gloria	Lander	76	31W TD	Lander	171
10W STY Herb	Lander	82	32W TY Beth	Lander	174
11W TS Ian	Lander	88	33W TY Carlo	Lander	178
12W TY Joy	Lander	92	34W TD	Edson/Lander	182
13W TY Kirk	Lander	97	35W TS	Lander	184
14W TS Lisa	Lander	105	36W STY Dale	Lander	187
15W TD	Lander	107	37W TS Ernie	Lander	194
16W TS Marty	Lander	109	38W TS	Guard/Lander	197
17W TD	Lander	113	39W TD	Edson/Lander	200
18W TY Niki	Lander	116	40W TD	Lander/McElroy	202
19W TY Orson	Lander	120	41W TD	Lander/McElroy	204
20W TY Piper	Lander	127	42W TY Fern	Lander/Boyer	206
21W TD	Lander	132	43W TS Greg	Lander	210
22W TS Rick	Lander	134			

3.2 North Indian Ocean Tropical Cyclones	214
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Individual Tropical Cyclone Narratives

<u>Tropical Cyclone</u>	<u>Author</u>	<u>Page</u>	<u>Tropical Cyclone</u>	<u>Author</u>	<u>Page</u>
TC 01B	Guard/Kubat	217	TC 05A	Guard/Kubat	228
TC 02A	Guard/Kubat	219	TC 06B	Carle	232
TC 03B	Guard/Kubat	222	TC 07B	Trehubenko	234
TC 04A	Guard/Kubat	225	TC 08B	Carle	236

4. SUMMARY OF SOUTH PACIFIC AND SOUTH INDIAN OCEAN TROPICAL CYCLONES	239
4.1 General	239
4.2 South Pacific and South Indian Ocean Tropical Cyclones	239
5. SUMMARY OF FORECAST VERIFICATION	247
5.1 Annual Forecast Verification	247
5.2 Comparison of Objective Techniques	261
5.3 Testing and Results	264
6. TROPICAL CYCLONE WARNING VERIFICATION STATISTICS	271
6.1 General	271
6.2 Warning Verification Statistics	271
7. TROPICAL CYCLONE (TC) SUPPORT SUMMARY	305
7.1 Combined SSM/I- and IR- Derived Rainrates for the Tropics	305
7.2 The Automated TC Forecasting System	305
7.3 Geophysical Fluid Dynamics- Navy (GFDN) TC Model	306
7.4 SSM/I -Derived Tropical Cyclone Structure	306
7.5 Operational Use of Scatterometer Data for TCs	308
7.6 Continued Study of Wind Distribution Forecasts Capabilities at JTWC	309
7.7 A Preliminary Study of GFDN- Generated Wind Distribution Forecasts ...	310
7.8 Progress on a Research Quality, Confidence-Based TC Intensity Database.	310
7.9 A Wind-Pressure Relationship for Midget TCs in the Western North Pacific	311
7.10 A Study of TC Intensity Changes Using The Digital Dvorak Algorithm ...	312
7.11 A Look at Global TC Activity During 1995: Contrasting High Atlantic Activity With Low Activity in Other Basins	312
7.12 Updating TC Satellite-Derived Position Code Number Criteria used by JTWC	313
7.13 A Technique for Estimating the Intensity of TCs Which are Undergoing Extratropical Transition	314
7.14 On the Ability of Operational Dynamic Models to Predict TC Intensity	315
7.15 Water Vapor and High Resolution Visually Tracked Winds for TC Applications	316
BIBLIOGRAPHY	317
APPENDIX A - Definitions	320
APPENDIX B - Names for Tropical Cyclones in the Western North Pacific Ocean and South China Sea	323
APPENDIX C - Contractions	324
APPENDIX D - Past Annual Tropical Cyclone Reports	328
APPENDIX E - Distribution List	329